A ROADMAP OF CONSOLIDATED CHEMICAL USER SAFETY & HEALTH REQUIREMENTS

FORWARD

Numerous requirements have been promulgated to protect workers, equipment, facilities and the environment. When work is performed, the specific requirements affecting the work must first be identified and incorporated into the work-plan. Because such requirements can number in the thousands, simply identifying all of the applicable chemical safety-related requirements that govern any work activity can be a monumental task. Concern over this was addressed in the 1994 DOE Chemical Vulnerability Study Management Response Plan, which identified the need for a complex-wide "Roadmap for Requirements". Similarly, discussions within the EFCOG/DOE chemical safety community have indicated that one of the main causes of continuing chemical safety deficiencies at DOE is the large number of requirements that govern chemical-related work at the Complex. Many of these requirements approach chemical safety from different perspectives and contain provisions that overlap and are sometimes contradictory and confusing. An EFCOG/DOE Chemical Safety Topical Committee (CSTC) Team, the Chemical User Safety and Health Requirements Roadmap (CUSHR) Team, undertook the task of looking into this issue.

Background

The EFCOG/DOE CSTC CUSHR Team conducted a limited review of how three DOE sites address compressed gases. Results showed that at these sites, only 50-70% of requirements were addressed in site documentation of chemical-related safety and health requirements. These results confirmed the view that while all DOE contractors who engage in the same work activities must follow the same requirements, many either do not know which requirements apply to their work or are confused by them. The Team concluded that this was likely due to the fact that multiple requirements from many varied sources frequently overlap, covering the same points in slightly different and sometimes conflicting ways.

To assist the sites in understanding and addressing the myriad requirements with which they must comply, the CUSHR Team committed to developing a series of activity-based chapters that consolidate the safety and health requirements that govern DOE chemical-related work activities, removing overlaps and resolving inconsistencies and contradictions.

Before beginning its work, the Team conducted a Chemical Storage Requirements Pilot in the summer of 2000 to see if this planned effort would be perceived as "value-added" for the DOE community. The pilot document provided consolidated chemical related safety and health requirements for chemical storage, a universal activity conducted by all that use chemicals throughout the Complex. A listing of consolidated requirements for safe chemical storage, along with a survey was distributed to chemical users across the Complex. The survey results demonstrated that the effort to consolidate requirements will be useful to chemical users throughout the Complex and should continue.

In support of this mandate to assist the sites with a requirements roadmap, the CSTC CUSHR Team has begun work on developing a series of activity-based chapters that consolidate the safety and health requirements that govern DOE chemical-related work activities. This document will be

produced as chapters that coordinate with the subjects covered in the DOE Chemical Management Handbook and will be published as a part of, or as a supplement to that Handbook.

Instructions for Use

This product consolidates existing, core safety and health requirements that all sites must follow when engaged in chemical-related activities. It is intended to consolidate overlapping and/or duplicative chemical-related safety and health requirements and to eliminate or resolve any inconsistencies or contradictions among those requirements. It serves only to **consolidate existing DOE and Federal chemical-related safety and health requirements.**

The listing of consolidated requirements includes "pointers" to the sources of those requirements, showing the user what the requirements are and where each comes from.
In addition to DOE Orders, it includes Occupational Safety and Health Administration (OSHA), National Fire Protection Association (NFPA), Uniform Building Codes (UBC), Uniform Fire Codes (UFC), American National Standards Institute (ANSI), and Compressed Gas Association (CGA) requirements that are cited in either DOE Order 440.1A or in OSHA standard 29CFR1910.6 ("Incorporation by Reference").

State and local codes are NOT included. U.S. Department of Agriculture (USDA) regulations are NOT addressed since the impact from these is considered to be negligible at DOE facilities. Similarly, U.S. Environmental Protection Agency (EPA) pesticide regulations are NOT addressed in this document since most DOE sites do not routinely store pesticides.

This product does NOT create any new or additional requirements.

In this web-based version of the document, wherever possible the referenced requirements are hyperlinked directly to their source documents. Since ANSI, CGA, NFPA, UFC and UBC documents are available only to subscribers to those organizations, the hyperlinks for those referenced requirements will take the reader only to the web pages of those organizations. Subscribers can then access the specific requirements of interest. Non-subscribers may be able to find these documents in their site libraries or can purchase them through the organizations' web pages.

The first chapter of this Requirements Roadmap product that has been completed is designated "Chapter 5, Chemical Storage" to coordinate with the DOE Chemical Management Handbook's chapter 2.5 that addresses the storage aspects of an effective Chemical Management Program. It contains a glossary of terms and explanatory notes for certain of the various requirements consolidations.

The 225 requirements included in this document come from a large number of sources that have different safety purposes. As a result, some of these requirements may not always be applicable to the work being performed at an individual site or facility. It is the responsibility of each user to determine the applicability of these requirements to their work and how they are implemented. The reference sources for the requirements included in this document can be used to determine the

applicability of those requirements to the work being performed. The source requirements are listed to the left of the corresponding
section of the document that consolidates the referenced requirements. If there is any question as to the applicability of a requirement or if it is thought that any requirement is taken out of context, then the reader can use the reference sources to research the original requirement. For each consolidation, a source document that is repeated is hyperlinked only once.

This draft chemical storage chapter is posted here for the review and use by the DOE Complex while the remaining chapters of this "Requirements Roadmap" project are under development. Once all of the chapters have been completed, the complete set will be posted on the DOE Chemical Safety web page and sent to all CSTC members and other interested parties across the Complex for their review and comment before being published as a part of the Chemical Management Handbook.

Please provide your comments to Dr. David Quigley, Chair of the CSTC CUSHR Team, at dq1@inel.gov

Consolidated Safety and Health Requirements for Chemical Storage

1.0 Introduction

This document identifies and consolidates existing user safety and health requirements and resolves contradictions found in DOE and Federal chemical-related safety and health regulations and National Standards that address the storage of ***chemicals*** (see def.) and ***chemical products*** (see def.). It specifically consolidates requirements found in the American National Standards Institute (ANSI) Z49.1, the Compressed Gas Association (CGA) G-1, and CGA P-1 , National Fire Protection Association (NFPA) 30, NFPA 45, NFPA 51, NFPA 55, NFPA 430, NFPA 432, the Occupational Safety and Health Administration (OSHA) regulations found at 29CFR 1910.6, 29CFR1910.106, 29CFR1910.134, 29CFR1910.253, 29CFR1926.350, and 29CFR1910.1200, and the Uniform Fire Code (UFC), the Uniform Building Code (UBC). It includes requirements that are cited in either DOE Order 440.1A or 29CFR1910.6 ("Incorporation by Reference"). State and local codes are NOT included. USDA regulations are NOT addressed since the impact from these is considered to be negligible at DOE facilities. Similarly, EPA pesticide regulations are NOT addressed in this document since most DOE sites do not routinely store pesticides.

This document is intended only to consolidate overlapping and/or duplicative chemical-related safety and health requirements and to eliminate or resolve any inconsistencies or contradictions among those requirements. The listing of consolidated requirements includes "pointers" to the sources of those requirements, showing the user what the requirements are and where each comes from.

This document does NOT create any new or additional requirements.

2.0 Applicability

This document applies to all locations that store chemicals or chemical products.
[NOTE: Throughout this document, the term "chemicals" is used to indicate chemicals and/or chemical products.]

This document does not apply to:

- chemicals stored in tanks with a greater than 735-pound water capacity;
- drums that have a greater than 55 gallon capacity;
- chemical distribution ***systems*** (see def.);
- storage containers attached to a system;
- waste chemical storage;
- the building or design of chemical storage areas [a design engineer who is acquainted with those requirements should be consulted before a chemical storage facility is built or before an existing facility is converted to chemical storage.]

Special laboratory requirements presented in this document apply to laboratories that are constructed and operated in accordance with NFPA 45, "Standard on Fire Protection for Laboratories Using Chemicals."

3.0 Definitions and Acronyms

ACGIH: American Conference of Governmental Industrial Hygienists.

ANSI: *American National Standards Institute.*

Approval: Authorization from subject matter experts or the appropriate level of management as defined in local site or facility procedures.

Chemical: Any element, compound or mixture of elements and/or compounds. A substance that a) possesses hazardous properties (including, but not limited to flammability, toxicity, corrosivity, reactivity); b) is included on any federal, state, or local agency regulatory list; or c) is associated with an MSDS. For the purpose of this document this definition also applies to ***chemical products*** (see def.)

Chemical Product: A mixture of any combination of two or more chemicals that may or may not be the result, in whole or in part, of a chemical reaction, and that itself has hazardous properties. Chemical products will have Material Safety Data Sheets (MSDS) associated with them and include materials such as paints, lubricants, cleaning agents, fuels, etc.

Chemical storage area: A location that is segregated by either physical barriers or a distance approved by a Fire Protection Engineer and is used to store any chemical except those that are classified as being ***low hazard*** (see def.). Example 1: If a flammable liquid storage cabinet is in a work area, then the inside of the cabinet is the storage area, not the entire work area. Example 2: Areas used to store chemicals that are of a low hazard are not considered to be chemical storage areas. Types of chemical storage areas include flammable liquid storage areas, oxidizer storage areas, and organic peroxide storage areas.

Class I flammable liquids: Class 1A, Class 1B, and Class 1C flammable liquids.

Class IA flammable liquids: Liquids having a flash point less than 73°F and boiling points below 100°F.

Class IB flammable liquids: Liquids having a flash point less than 73°F and boiling points at or above 100°F.

Class IC flammable liquids: Liquids having a flash point at or above 73°F and below 100°F.

Class II combustible liquids: Liquids having a flash point greater than 100°F but less than or equal to140°F.

Class IIIA combustible liquids: Liquids having a flash point greater than 140°F but less than or equal to 200°F.

Class 1 Oxidizer: An oxidizer that will not result in spontaneous combustion when it comes into contact with combustible materials, but will slightly increase the burning rate of combustibles that have already been ignited. See Appendix VI-A of the Uniform Fire Code for examples.

Class 2 Oxidizer: An oxidizer that may cause spontaneous ignition when it comes into contact with combustible materials or that will cause a moderate increase in the rate at which a combustible will burn. See Appendix VI-A of the Uniform Fire Code for examples.

Class 3 Oxidizer: An oxidizer that will undergo a vigorous self-sustained decomposition when exposed to contamination or heat or that will cause a severe increase in the rate at which combustibles will burn. See Appendix VI-A of the Uniform Fire Code for examples.

Class 4 Oxidizer: An oxidizer that will explosively decompose upon exposure to heat, shock or contaminants. See Appendix VI-A of the Uniform Fire Code for examples.

Fire area: An area in a building that is separated from the rest of the building by a one- hour fire barrier. All penetrations through this fire barrier must be constructed to maintain the one-hour fire resistance.

Flammable liquids storage rooms: Rooms that are designed according to 29CFR1910.106 (d)(4) for the storage of flammable and combustible liquids.

Flammability Rating of "0" or "1": Liquids, solids or semi-solids that have a flash point above 200°F or those materials which will not burn when exposed to a temperature of 1500°F for 5 minutes.

***FM*:** Factory Mutual

Inside room: A room totally enclosed within a building and having no exterior walls.

Laboratory units: For a complete overview of laboratory units and their definition, see NFPA 45, Fire Protection for Laboratories Using Chemicals.

LC_{50}: The concentration of a vapor or gas that will kill 50% of a test population. Exposure periods are typically for one hour unless otherwise stated.

Low hazard chemicals[1]: Chemicals that have an NFPA flammability rating of "0" or "1"; a health hazard rating of "0" or "1"; a reactivity rating of "0"; and no special hazard rating such as "oxidizer", "water reactive", or "hazardous polymerization" per NFPA 704, Identification System for Fire Hazards of Materials.

MSDS [2]: Material Safety Data Sheet

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1 **Low Hazard Chemical**: This definition refers to the NFPA 704 hazard identification numbers, which includes information on how to use them to determine if a chemical is a "low hazard" chemical. A well-developed set of criteria is needed in order to determine appropriate ratings for those chemicals that have not been rated. Criteria for these ratings have been well defined in NFPA 704. Those criteria can be used to determine hazard ratings for chemicals that have yet to be evaluated. (While other rating systems exist, none is as well- accepted nor does any have criteria that are as well defined for the evaluation of chemicals as does the NFPA 704 system.) It should be noted, however, that NFPA 704 criteria are developed for acute exposures only. Chronic effects, such as carcinogenicity, should be factored into any evaluation when determining health ratings. Information concerning chronic health hazards can be found in numerous resources such as Tomes®, the ACGIH "Guide to Occupational Exposure Threshold Limit Values", and the NIOSH "Pocket Guide to Chemical Hazards".

2 **Material Safety Data Sheets (MSDS):** Although a manufacturer may provide an MSDS for a chemical, the issuance of that MSDS does not necessarily indicate that the material is hazardous. Some manufacturers develop MSDSs for all their chemicals whether the material is hazardous or not.

NFPA: National Fire Protection Association

NFPA Health hazard rating of "3" (for a gas): Per NFPA 704, "Identification of the Hazards of Materials for Emergency Response", any gas whose LC_{50} (see def.) for acute inhalation toxicity is greater that 1000 parts per million (PPM) but less than or equal to 3000 PPM.

NFPA Health hazard rating of "4" (for a gas): Per NFPA 704, "Identification of the Hazards of Materials for Emergency Response", any gas whose LC_{50} for acute inhalation toxicity is less than or equal to 1000 PPM.

NIOSH: National Institute for Occupational Safety and Health.

Oxidizer: As per 29CFR1910.1200, a chemical other than a blasting agent or explosive as defined in 29CFR1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

Outdoor storage locker: A moveable, prefabricated structure, manufactured at a site other than the final location of the structure and transported completely assembled or in a ready to assemble package to the final location. It is intended to meet local, state, and federal requirements for the outside storage of hazardous materials.

Segregated warehouse: A separated or detached building used specifically for warehousing-type operations.

Sprinklered area: An area that has an overhead system designed to spray water down from sprinkler heads during a fire.

Storage: A chemical(s) set aside for future use or safekeeping or an inventory of compressed or liquefied gases in containers that are not in the process of being used, examined, serviced, refilled, loaded, or unloaded.

System: Piping, pumps and/or containers that are attached together so that the collection can perform some specific function.

TBD: To be determined at a later date.

Toxic gas: Any gas that has a National Fire Protection Association (NFPA) ***health hazard rating of 3 or 4*** (see def.) per NFPA 704, Identification System for Fire Hazards of Materials.

UL Listed: Listed by the Underwriter's Laboratory to indicate special construction requirements have been met.

UBC: Uniform Building Code.

UFC: Uniform Fire Code.

Upright position: The position a cylinder is in when the valve is located at a position higher than any other on the tank.

Water reactive material: A substance that will spontaneously react with water to release toxic gases, flammable gases, or amounts of heat that could become significant (e.g., resulting in splattering, pressure-volume explosions). It includes those materials that can form explosive mixtures with water.

4.0 Requirements

DOE Order 440.1A; 29CFR1910.6

[NOTE: The information that follows is a consolidation of existing Federal safety and health requirements and National Standards that relate to the storage of chemicals. It therefore contains "shall" statements that are taken from, or based on "shall" statements in those existing requirements. While NFPA and CGA requirements that are referenced here are not, in and of themselves mandatory, they are made mandatory by OSHA regulation 29CFR1910.6, which incorporates them by reference. DOE Order 440.1A mandates compliance with OSHA regulations found in Title 29 of the Code of Federal Regulations (CFR). NFPA and CGA requirements referenced here are thereby made mandatory for DOE contractors through contracts that include DOE Order 440.1A. Please see the Introduction to this section of the DOE Chemical Management Handbook for more information.]

4.1 General

NFPA 45, 7-2.3.3; UFC Article 80, 8001.15

4.1.1 Facilities shall be evaluated to determine chemical storage limits, allowable chemical container storage sizes, and stacking limits. Quantities of chemicals stored shall remain within those limits.[3]

NFPA 430, 2-1.1; NFPA 430, 2-10.1; NFPA 432, 2-7.1; NFPA 432, 2-7.2

4.1.2 The identification or design of ***chemical storage areas*** (see def.), or maintenance work on chemical storage areas shall be reviewed.[4]

NFPA 430, 2-6.1

4.1.2.1 New facility design shall take into account the need for containment to protect the environment from oxidizers, fire suppression agents, and decomposition products

NFPA 430, 2-6.2

4.1.2.2 ***Approval*** (see def.) of chemical storage areas shall take into consideration the potential for large quantities of smoke and toxic fumes, especially as storage affects manual fire fighting operations, building egress, and evacuation of adjacent facilities.

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3 [4.1.1] Facility chemical quantity limits stem primarily from the Uniform Fire Code and the Uniform Building Code. These may be modified by NFPA 45 for laboratories, by local ordinances or by other codes that are specific to one particular class of chemicals such as NFPA 30, "Flammable and Combustible Liquids".

4 [4.1.2] There are restrictions and requirements for welding and cutting activities at locations where chemicals are used and stored. Consult your local welding and cutting program to determine what these requirements are.

ANSI Z 49.1, 10.8.2.1;
CGA G-1, 4.2.14;
CGA P-1, 3.7.3.2;
NFPA 30, 4-7.4;
NFPA 51, 2-2.1;
NFPA 55, 2-1.2;
29CFR1926.350(a)(11);
29CFR1910.253 (b)(2)(i i);
UFC Article 80, 8001.11.2.

4.1.3 Chemical storage areas shall be secured using physical or administrative controls to prevent unauthorized entry. [5]

NFPA 430, 2-9.2;
NFPA 432, 2-6

4.1.4 "No smoking" signs shall be posted at all entrances to chemical storage areas.

NFPA 30, 4-8.5

4.1.5 Ignition sources such as open flames, spark producing equipment, static electricity, and other hot sources shall not be permitted in areas where chemicals are stored unless reviewed and approved.[6]

29CFR1910.1200 (f);
NFPA 430, 2-2.3

4.1.6 All chemicals shall be properly labeled.

CGA P-1, 3.7.2.1;
NFPA 45, 7-2.3.4;
NFPA 55, 2-1.3;
NFPA 55, 2-1.6.3.A;
NFPA 430, 2-4.2;
NFPA 430, 2-4.3;
NFPA 432, 2-10.4;
UFC Article 80, 8001.11.8

4.1.7 Chemicals shall be stored compatibly and in a way to prevent contact with incompatible materials. This includes preventing liquids from flowing out of a chemical storage area into another area where they may come into contact with incompatible materials.

[Exception: NFPA 430, 2-4.2 exempts packaging materials, pallets, and other dunnage from this requirement. However, hydrogen peroxide (Classes II to IV as defined by the Uniform Building Code or Uniform Fire Code) cannot be stored on wooden pallets.] [7]

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5 [4.1.3] It is recommended that a graded approach be used in meeting this requirement.

6 [4.1.5] Restrictions and requirements for welding and cutting activities at locations where chemicals are used and stored are based on specific conditions. Consult your local facility welding and cutting program to determine what requirements are applicable to specific activities and conditions at your site.

7 [4.1.7] This requirement is intended to keep chemicals safe during routine storage and during an upset condition such as a fire. Therefore, chemicals that are only incompatible at elevated temperatures are still considered incompatible during routine storage conditions due to the possibility of fire or other upset condition. This document does not intend to direct which compatibility scheme should be used. Each site or facility must determine for itself which compatibility scheme they will use to implement this requirement.

NFPA 432, 2-3

4.1.7.1 All construction materials in a chemical storage area shall be compatible with those chemicals being stored.

NFPA 55, 2-1.6.3.c

4.1.7.2 Floors of chemical storage areas shall be constructed of noncombustible or limited combustible materials.

NFPA 45, 7-2.3.1

4.1.7.3 Storage of chemicals in the open shall be kept to a minimum.

NFPA 430, 2-4.2.1

4.1.7.4 Special care shall be taken to prevent the contamination of chemicals in storage.

NFPA 430, 2-4.2.2;
UFC Article 80, 8001.11.8.A

4.1.7.5 When flammable and combustible liquids are stored in ***segregated warehouses*** (see def.) with oxidizers, they shall be separated from those oxidizers by a distance of 25 ft. with dikes, drains, or sloping floors present to prevent the flammable liquids from encroaching on the separation.

NFPA 45, 7-2.3.5;
NFPA 45, 10-3.2

4.1.8 Chemicals that might become hazardous upon prolonged storage shall be dated when first opened and evaluated for safety every 6 months thereafter.

NFPA 45, 7-2.3.5

4.1.8.1 Chemicals that are found to be unsafe and cannot be made safe shall be disposed of safely and in compliance with applicable requirements.

CGA G-1, 4.2.15;
CGA G-1, 4.2.2;
CGA G-1, 4.2.6;
CGA P-1, 4.2.2.1;
CGA P-1, 4.5.4.2.1;
29CFR1910.106 (d)(4)(iv);
NFPA 30, 4.3;
NFPA 45, 7-2.3.6
NFPA 51, 2-2.2;
NFPA 51, 2-3.2;
NFPA 55, 2-2.2.3;
NFPA 55, 3-1.2;
NFPA 55, 3-1.3;
NFPA 432, 2-5.4

4.1.9 Indoor chemical storage areas shall have either natural or mechanical ventilation designed to provide a minimum of six air exchanges per hour and shall discharge the air a minimum of 50 ft. from any air intakes for air handling systems, air compressors, etc.

[Exception: Under NFPA 30, 4.3 and NFPA 45, 7-2.3.6 this requirement does not apply to flammable liquid storage cabinets.]

29CFR1910.106 (d)(4)(iv);
NFPA 55, 3-1.3.b

4.1.9.1 A manual shutoff shall be provided outside the ***toxic gas*** (see def.) and flammable/combustible liquids storage areas adjacent to the entry door and shall be labeled “Ventilation System Emergency Shutoff.”

NFPA 55, 3-1.3.c

4.1.9.2 Exhaust ventilation shall not be recirculated within any room or building.

NFPA 432, 2-11.1

4.1.10 Good housekeeping shall be maintained in areas where chemicals are stored.

29CFR1910.106(d)(5)(i);
NFPA 30, 4-4.3.2;
NFPA 30, 4-5.1.3;
NFPA 30, 5-12.7.5.

4.1.10.1 Aisles established for the movement or egress of personnel shall be maintained clear of obstructions, including stored chemicals.

NFPA 30, 4-7.4;
NFPA 30, 5-12.7.4
NFPA 430, 2-13.1;
NFPA 432, 2-9.1.

4.1.10.2 Accumulation of wastes, debris, weeds, and other combustible materials shall be prohibited.

NFPA 430, 2-13.2;
NFPA 432, 2-9.2

4.1.10.3 Spilled chemicals and broken containers shall be immediately managed using appropriate procedures.

NFPA 430, 2-13.3

4.1.10.4 Each used and empty container shall be stored in a manner appropriate for the chemical that existed in that container until it is disposed of or cleaned;

OR

stored in a detached or ***sprinklered area*** (see def.) until disposed of or cleaned.

NFPA 430, 2-13.4

4.1.10.5 Storage operations shall be arranged to prevent the accumulation of fugitive dust from the stored chemical.

NFPA 45, 7-2.3.1

4.1.11 Hazardous chemicals stored in the open in laboratory work areas shall be kept to the minimum necessary for the work being done.

4.2 Compressed Gases

NFPA 45, 8-1.6.5

[NOTE: In a laboratory a compressed gas cylinder shall be considered "in use" if it is:

a) connected through a regulator to deliver gas to a laboratory operation; or

b) connected to a manifold being used to deliver gas to a laboratory operation; or

c) *a single cylinder secured alongside the cylinder in (a) above as the reserve cylinder.]*

NFPA 55, 4-1.1

4.2.1 Hazard identification signs shall be placed at all entrances to compressed gas storage areas.

NFPA 55, 4-1.2.A

4.2.1.1 Signs shall be in English and/or shall use symbols.

NFPA 55, 4-1.2.A

4.2.1.2 Signs shall not be obscured or removed.

CGA G-1, 4.2.9;
CGA P-1, 3.7.1;
29CFR1910.253(b)(3)(i);
NFPA 55, 2-2.1.4.
NFPA 55, 4-1.2.b;
NFPA 55, 7-1.1

4.2.1.3 Signs shall prohibit smoking or an open flame within 20 ft of where toxic, pyrophoric, oxidizing, or flammable gases are stored.

ANSI Z49.1, 10.8.2.1;
29CFR1926.350 (a)(11);
CGA P-1, 3.7.2.2;
CGA P-1, 3.7.3.2;
CGA G-1, 4.2.4;
NFPA 51, 2-2.1,
NFPA 55, 2-1.6.1.c

4.2.2 Compressed gas cylinders shall be stored away from stairways, elevators, exit routes, or gangways, in assigned places where they will not be exposed to physical damage (for example, damage from vehicles, damage from falling ice, etc.).

ANSI Z49.1, 10.8.2.1;
CGA G-1, 4.2.8;
CGA P-1, 3.7.4.1;
CGA P-1, 3.7.4.2;
29CFR1910.253 (b)(2)(ii);
NFPA 55, 2-2.1.6;
NFPA 55, 6-6

4.2.3 Compressed gas cylinders shall be stored in an ***upright position*** (see def.) with their valve protection caps in place and secured to prevent cylinders from falling over or being knocked over.

[Exception: All requirements cited here indicate that upright storage is not required for lecture bottles or cylinders used in self-contained breathing apparatus.]

NFPA 55, 2-1.6

4.2.4 Outdoor storage areas of compressed gases shall have a minimum of 25% of the area's perimeter open to the atmosphere.

NFPA 55, 2-1.6.1.a

4.2.4.1 Storage areas shall be kept clear of dry vegetation and combustible materials for a minimum distance of 15 ft in all directions.

CGA P-1, 3.7.3.1;
CGA G-1, 4.2.13;
NFPA 55, 2-1.6.1.b

4.2.4.2 Cylinders stored outdoors shall not be placed in direct contact with the earth or on surfaces where water can accumulate.

NFPA 55, 2-1.6.1.d

4.2.4.3 Outdoor compressed gas storage areas may be covered with canopies of a noncombustible construction.

ANSI Z49.1, 10.8.1.8;
CGA G-1, 4.2.3;
CGA P-1, 3.7.2.1;
NFPA 51, 2-2.1;
NFPA 55, 2-1.6.2

4.2.5 Compressed gas cylinders in storage shall not be heated above 125°F [8].

ANSI Z49.1, 10.8.2.2;
ANSI Z49.1, 10.8.2.3;
CGA G-1, 4.2.5;
CGA P-1, 3.7.2.1;
CGA P-1, 4.2.4.1;
CGA P-1, 4.4.4;
29CFR1926.350 (a)(10);
29CFR1926.350 (a)(11);
29CFR1910.253 (b)(2)(ii);
29CFR1910.253 (b)(4)(iii);
NFPA 51, 2-2.1;
NFPA 51, 2-4.3;
NFPA 55, 2-1.6.3.e

4.2.6 Compressed gases in storage shall be segregated from incompatible materials or combustibles in storage by either a distance of 20 ft. or by a noncombustible partition with a fire resistance rating of ½ hour and extending not less than 18 inches above and to the sides of the stored material. The noncombustible barrier shall be five feet high for those cylinders that are less than three and a half feet tall.

[Exception: Under ANSI Z49.1 and NFPA 55 welding gases located on a weld cart are considered to be "in use" and not in storage. This is also consistent with the NFPA 45 definition of "in use". Under these cited standards, then, this requirement does not apply to oxygen and fuel gases on a weld cart. Similarly, since oxygen and fuel gases on a weld cart are considered to be "in use" under these standards, they also are not required to be segregated from each other.]

[NOTE: The intent of these requirements is to discourage the manufacture of unsafe weld carts and to prevent the practice of removing welding gases from carts at the end of every work shift or day, since this additional handling of the gases is considered to be inherently more hazardous than is their temporary storage on weld carts. It should be noted , however, that keeping oxygen and fuel gases on a weld cart for excessively long periods without any actual use would counter the intent of these requirements.]

NFPA 55, 2-2.1.5

4.2.6.1 Flammable gas cylinders shall be stored a minimum distance of 20 ft. from storage of flammable and combustible liquids and solids.

29CFR1910.253 (b)(3)(i)

4.2.7 The inside storage of more than 2,000 standard cubic ft. (scf) of flammable gas, or more than 300 pounds of liquefied petroleum gas requires a separate room, compartment, or special storage building.

NFPA 55, 2-2.1.7.a

4.2.8 Storage in one fire area of multiple groups of cylinders containing flammable gas, where the total volume of gas in each group is less than 2,500 scf, shall be permitted when groups are separated from each other by a minimum of 100 ft.

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8 [4.2.5] This requirement includes the storage of compressed gas cylinders in direct sunlight where the sunlight may cause the cylinder to overheat.

NFPA **55, 2-2.1.7.b**

4.2.8.1 Groups may be separated from each other by masonry walls with a fire resistance rating of 2 hours instead of by a minimum distance.

NFPA **55, 2-2.1.8**

4.2.8.2 Different flammable gases shall be allowed to be stored together.

CGA G-1 4.2.6;
NFPA 51, 2-3.1;
NFPA 55, 2-2.2.1.a

4.2.9 Flammable gases with a collective volume between 2,501 and 5,000 scf, when stored indoors, shall be stored in rooms or enclosures with a minimum 1-hour fire resistance rating.

NFPA 55, 2-2.2.2.1

4.2.9.1 Multiple groups of flammable gas cylinders in one sprinklered fire area shall be stored a minimum of 100 ft. apart.

NFPA 51, 2-3.2;
NFPA 55, 2-2.3.1

4.2.10 Flammable gases with a collective volume greater than 5,000 scf, when stored indoors, shall be stored in a room or enclosure with a minimum fire resistance of 2 hours.

NFPA 51, 2-3.2;
NFPA 55, 2-2.3.2

4.2.10.1 Rooms used to store compressed gases shall be sprinklered according to NFPA 13, "Standard for the Installation of Sprinkler Systems."

NFPA 55, 3-1.1

4.2.11 Compressed gas storage areas that are used to store toxic gases indoors shall be equipped with a continuous monitoring system that would provide warning of toxic gas concentrations that could present a hazard to life.

NFPA 55, 3-1.2

4.2.11.1 This system shall not be required for those gases with an ***NFPA health hazard rating of "3"*** (see def.), when the upper range of the odor threshold is below the permissible exposure limit for that gas.

NFPA 55, 3-1.4

4.2.12 Outdoor storage areas of toxic gases shall be located 75 ft from a line of property, public ways, places of assembly, etc., and shall be secured from unauthorized access.

NFPA 55, 3-1.5

4.2.13 Cylinders of toxic gases, whether full, partially full, or empty shall have valve protection devices or caps and gas-tight valve outlet caps or plugs in place while in storage.

NFPA 55, 3-2.1

4.2.14 Gases with an ***NFPA health hazard rating of "4"*** (see def.) that are stored indoors shall be placed in gas cabinets having positive exhaust ventilation.

NFPA 55, 3-2.2

4.2.14.1 Outdoor storage of gases with a health hazard rating of 4 shall require at least one gas cabinet for the handling and storage of leaking cylinders within or adjacent to the storage area.

NFPA 55, 3-2.3

4.2.14.2 Gas cabinets shall have the exhaust connected to treatment systems.

NFPA 55, 3-3

4.2.15 Storage areas for gases having an NFPA health hazard rating of "3" shall have readily available equipment onsite to prevent gas leaking into the building or atmosphere.

4.2.16 Compressed gas storage cabinets shall be designed according to NFPA 55.

NFPA 55, 7-4.2

4.2.16.1 Compressed gas storage cabinets shall operate at a negative pressure in relation to surrounding areas.

NFPA 55, 7-4.1

4.2.16.2 Compressed gas storage cabinets shall be labeled on the front in high contrasting background red letters a minimum of 1 inch high stating: "Hazardous—Keep Fire Away."

NFPA 55, 7-2.1

4.2.17 Storage rooms or areas for the storage of toxic or pyrophoric gases shall be protected by an automatic fire extinguishing system in accordance with either NFPA 13, "Standard for the Installation of Sprinkler Systems", or NFPA 15, "Standard for Water Spray Fixed Systems for Fire Protection."

NFPA 55, 7-2.2

4.2.18 A fire alarm activation station or approved emergency signal device shall be located adjacent to exit doors of buildings and rooms or areas where toxic, pyrophoric, or flammable gases are stored. Activation of the system shall sound a local alarm.

NFPA 55, 7-2.3

4.2.19 An approved, supervised smoke detection system shall be provided in rooms or areas where toxic, flammable, or pyrophoric gases are stored indoors. Activation of the system shall sound a local alarm.

NFPA 55, 7-2.4

4.2.20 Manual alarm, emergency signal, detection, or automatic extinguishing systems shall be supervised by an approved centralized or remote station service or shall initiate either an audible or visual signal at a constantly attended location.

29CFR1910.134;
NFPA 55, 7-5.1

4.2.21 Where toxic gases are stored, a minimum of two NIOSH approved self-contained breathing apparatus (SCBAs) shall be kept available at all times for use in upset conditions. They shall be cleaned and disinfected after each use, properly maintained and stored, inspected at least monthly, and checked for proper function before and after each use.

CGA P-1, 3-10.4.1; CGA P-1, 4.5.2.3.1.

4.2.21.1 NIOSH approved SCBAs shall also be provided where protection is deemed necessary for entry into atmospheres containing asphyxiant or corrosive gases. [9]

NFPA 55, 7-5.2

4.2.21.2 At least two employees who are trained in the use of SCBAs shall be available at all times.

CGA P-1, 3.10.4.1

4.2.21.3 One of the two SCBAs present shall be in the possession of a qualified backup person present at the scene when the SCBAs are being used.

NFPA 55, 7-5.1

4.2.21.4 SCBAs shall be compatible with those gases expected to be present to prevent the degradation of the SCBA or any of its components.

NFPA 55, 7-5.1

4.2.21.5 SCBAs shall be located near the immediate area and in a location that provides safety to those expected to wear them.

NFPA 55, 7-5.1; NFPA 55, 7-2.4

4.2.21.6 Where the hazard presented by the compressed gas is other than respiratory, then additional appropriate protective equipment shall be provided.

4.3 Flammable and Combustible Liquids

NFPA 30, 4-4.3.3; NFPA 30, 4-4.3.4; 29CFR1910.106 (d)(4)(v)

4.3.1 Aisles in areas that qualify as indoor liquid storage areas as per NFPA 30, "Flammable and Combustible Liquids Code", shall be 4 ft wide. Aisles in other flammable liquid storage areas shall be 6 ft wide.

29CFR1910.106 (d)(5)(vi)(f)

4.3.1.1 Aisles at least 3 ft wide shall be provided where necessary to allow for access to doors, windows, or standpipe connections.

NFPA 30, 4-4.3.5; NFPA 30, 4-5.1.5; NFPA 30, 4-5.2.6

4.3.2 ***Class I flammable liquids*** (see def.) shall not be stored in basement areas. ***Class II and Class IIIA combustible liquids*** (see def.) shall not be stored in basement areas unless those areas are protected with automatic sprinkler systems.

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9 [4.2.21.1] Any other respirator used must go through a NIOSH approval process for equivalency. This process must be described in the facility's written respiratory protection program.

NFPA 30, 4-5.1.3

4.3.3 Class I flammable liquids shall not be stored such that a fire in the liquids storage area would prevent egress from the area.

NFPA 30, 4-5.2.9.a

4.3.4 In general purpose warehouses, flammable and combustible liquids shall not be stored in the same pile or on the same rack as ordinary combustibles.

NFPA 30, 4-4.3.6;
NFPA 30, 4-4.3.7;
NFPA 30, 4-5.2.9.b

4.3.4.1 Ordinary combustibles, other than those used for packaging flammable liquids, shall be stored a minimum of 8 ft from flammable or combustible liquids.

NFPA 30, 4.5.2.9.a

4.3.4.2 Where flammable liquids are packaged together with ordinary combustibles, such as in kits, storage shall be considered on the basis of whichever commodity predominates.

NFPA 30, 4-4.3.7

4.3.5 Storage of empty or idle pallets inside a flammable liquid storage area shall not exceed 2,500 ft.^{2} and 6 ft. in height.

NFPA 30, 4-4.3.8;
29CFR1910.106 (d)(5)(vi)(c)

4.3.6 Containers in piles shall be stacked in such a manner as to provide stability and to prevent excess stress on container walls.

NFPA 4-4.3.8;
29CFR1910.106 (d)(5)(vi)(d)

4.3.6.1 Portable tanks stored over one tier high shall be nested securely without dunnage.

NFPA 30, 4-4.3.8

4.3.6.2 Material handling equipment shall be suitable to handle containers and tanks safely at the upper tier level.

NFPA 30, 4-4.4.2;
29CFR1910.106 (d)(4)(v)

4.3.7 Containers over 30 gallons in size that contain Class I or Class II liquids shall not be stored over one level high in ***inside rooms*** (see def.).

NFPA 30, 4-4.3.9;
29CFR1910.106 (d)(5)(vi)(e)

4.3.8 No stack of flammable or combustible liquids shall be closer than 3 ft. to the nearest beam, chord, or other construction, and shall be 3 ft. below sprinkler deflectors, discharge orifices of water spray, or other overhead fire protection systems.

NFPA 30, 4-8.4;
29CFR1910.106 (d)(7)(i)

4.3.9 Suitable fire control devices shall be available at locations where flammable and combustible liquids are stored.

29CFR1910.106 (d)(7)(i)(a);
29CFR1910.106 (d)(7)(i)(b)

4.3.10 At least one portable fire extinguisher having a rating of not less than 40-B units shall be located outside but not more than 10 ft. from any door to a flammable and combustible liquids storage room or any area where Class I or Class II liquids are stored.

NFPA 30, 4-8.5.1; 29CFR1910.106 (d)(7)(iv);

4.3.11 ***Water reactive materials*** (see def.) shall not be stored in the same area with flammable or combustible liquids.[10]

NFPA 30, 4-5.2.4

4.3.12 Class I and Class II liquids in plastic containers shall only be stored in ***flammable liquids storage rooms*** (see def.) or flammable liquid storage cabinets.

NFPA 30, 4-5.1.4

4.3.13 Liquids used for building maintenance, painting, or other similar infrequent maintenance purposes shall be permitted to be stored temporarily in closed containers outside of flammable liquids storage cabinets or flammable liquids storage areas, if the amount stored does not exceed a 10-day supply at anticipated use rates.

NFPA 45, 2-2 (b); 29CFR1910.106 (e)(2)(ii)(b)(1)

4.3.14 The quantity of flammable and combustible liquids that can be stored outside a flammable liquids storage room or flammable liquids storage cabinet is as follows[11]:

A. 25 gallons of Class IA liquids in containers per ***fire area*** (see def.), and

B. 120 gallons of Class IB, IC, II, or IIIA liquids in containers per fire area.

OR

A. 570 L (150 gallons) of Class I liquids in sprinklered ***laboratory units*** (see def.), and

B. 757 L (200 gallons) of Class I, II, and IIIA liquids in sprinklered laboratory units.

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10 [4.3.10] This requirement is intended to protect water reactive chemicals from exposure to water in water based fire suppression systems that may be used where flammable liquids are stored. Spraying water on a water reactive material during an upset condition could increase the severity and danger of the upset condition. While not required, consideration should be given to applying a similar restriction in oxidizer storage areas. See section 4.4.2.

11 [4.3.13] Numerous types of storage areas (e.g., cutoff storage rooms, mercantile storage areas, inside storage rooms, etc.) can exist. Storage limits for laboratories have been defined in 4.3.14. 4. There are many other types of storage areas and limits for each of these are not included in this document. A fire protection engineer should be consulted to determine storage limits for these other storage areas.

4.3.15 With the exception of Section 4.3.12 and 4.3.13, all Class I, II, and IIIA flammable and combustible liquids not in a flammable liquids storage room shall be stored in flammable liquid storage cabinets when not in use.

NFPA 30, 4-3.1

4.3.15.1 The total quantity of liquids shall not exceed 120 gallons per cabinet with not more than 60 gallons of Class I and Class II liquids stored in one cabinet.

NFPA 30, 4-3.3

4.3.15.2 Flammable liquids storage cabinets shall be FM approved or UL listed.

NFPA 30, 4-3.2

4.3.15.3 Not more than three flammable liquid storage cabinets are allowed in any one fire area, except as follows:

[Exception 1: In an industrial occupancy, additional groups of storage cabinets can be located in any fire area if a minimum100-foot separation is maintained.

Exception 2: In an industrial occupancy that is protected by an automatic fire sprinkler system, the number of cabinets can be increased to 6 in a group.

Exception 3: In a laboratory fire area, the number of Flammable liquid storage cabinets is not limited; however, the total quantity of flammable and combustible liquids is limited to the quantities as defined in 4.3.14.4.]

NFPA 45, 2-2.1.3

4.3.15.4 The maximum amount of Class I, II, and IIIA flammable and combustible liquids that can be stored in a laboratory fire area is 400 gallons of which the maximum amount of Class I flammable liquids is 300 gallons.

NFPA 30, 4-6.4

4.3.16 Sites for ***outdoor storage lockers*** (see def.) shall be reviewed to ensure proper placement, separation, etc.

NFPA 30, 4-6.1

4.3.16.1 Multiple outdoor storage lockers at a given site shall be separated according to requirements in NFPA 30, "Flammable and Combustible Liquids Code".

NFPA 30, 4-6.4.4.1

4.3.16.2 In outdoor storage lockers, containers in their original shipping packages shall be permitted to be stored either on pallets or in piles, while unpacked containers shall be stored on shelves or on the floor.

NFPA 30, 4-6.4.4.2

4.3.16.3 No other flammable or combustible materials shall be stored at designated outdoor storage locker sites.

NFPA 30, 4-6.4.4.3

4.3.16.4 Outdoor storage lockers shall be placarded according to NFPA 704, "Identification of the Hazards of Materials for Emergency Response".

4.4 Oxidizers

[NOTE: *Additional requirements can be found in NFPA 430, "Code for Storage of Solid and Liquid Oxidizers", when quantities exceed 4,000 pounds of Class 1 oxidizer (see def.), 1,000 pounds of Class 2 Oxidizer (see def.), 200 pounds of Class 3 Oxidizer (see def.), or 10 pounds of Class 4 Oxidizer (see def.). Oxidizer classes are defined in NFPA 430, the "Uniform Fire Code (UFC)", and the "Uniform Building Code (UBC)".*]

NFPA 430, 2-2.1

4.4.1 Oxidizer storage areas shall be conspicuously identified with the words "Class (appropriate classification number) Oxidizers."

NFPA 430, 2-2.2

4.4.1.1 Areas used to store oxidizers of different classes shall be marked as containing the most severe hazard.

NFPA 430, 2-11.6

4.4.2 Water based manual fire fighting equipment shall be used in oxidizer storage areas.[12]

NFPA 430, 2-11.6.

4.4.2.1 The placement and use of dry chemical extinguishers containing ammonium compounds (Class ABC) shall be prohibited in oxidizer storage areas where oxidizers that can release chlorine are stored.

NFPA 430, 2-11.6.2

4.4.2.2 Halon extinguishers shall not be used in oxidizer storage areas.

NFPA 430, 2-13.5

4.4.3 Combustible construction materials that could come into contact with oxidizers shall be coated with a compatible material to prevent their impregnation with the oxidizers.

NFPA 430, 2-13.5

4.4.4 Absorptive packing materials, wooden pallets, etc., that are exposed to water containing oxidizers or that contain water soluble oxidizers, and are exposed to water shall be immediately relocated to a safe outside area and properly disposed of.

NFPA 430, 2-8.1

4.4.5 Oxidizers shall not be stored where they can be heated to within 25°F of their decomposition temperature or above 120°F, whichever is lower.[13]

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12 [4.4.2] Oxidizer storage areas and flammable liquids storage areas require water- based fire suppression systems. While there are no requirements to keep water reactive materials away from oxidizers, when storing oxidizers, consideration should be given to the additional hazard posed by the presence of water reactive materials when water suppression systems are activated.

13 [4.4.5] Attention should be used to ensure that oxidizers stored in direct sunlight are not heated above allowed temperatures by radiant heating.

4.5 Organic Peroxides

NFPA 432, 2-1

4.5.1 Chemical storage areas used for the storage of organic peroxides shall be conspicuously identified with the words “Organic Peroxides” and by the class.

NFPA 432, 2-1.1

4.5.1.1 Areas used to store organic peroxides of different classes per NFPA 432, "Code for the Storage of Organic Peroxide Formulations", shall be marked as containing the most severe hazard.

NFPA 432, 2-1.2

4.5.1.2 Packages containing organic peroxide formulations shall be individually marked with chemical name and other pertinent information to allow proper classification.

NFPA 432, 2-1.3

4.5.1.3 Packages of organic peroxides that require temperature control shall be marked with the recommended storage range.

NFPA 432, 2-11.2

4.5.2 A clear space of at least 2 ft. shall be maintained between organic peroxide storage and uninsulated metal walls.

NFPA 432, 2-11.3

4.5.3 Incompatible materials and flammable liquids shall not be stored within 25 ft. of organic peroxide formulations in chemical storage areas.

[NOTE: O*rganic peroxide formulations that are also classified as flammable liquids may be stored with other organic peroxide formulations.*]

NFPA 432, 2-11.3.2

4.5.3.1 If a 25-foot separation cannot be maintained, then a 1-hour, liquid-tight fire barrier shall be permitted.

NFPA 432, 2-11.4

4.5.4 Only closed containers shall be permitted in an organic peroxide storage area.

NFPA 432, 2-11.6

4.5.5 Fifty-five-gallon drums of organic peroxide formulations shall not be stacked.

NFPA 432, 2-4.1;
NFPA 432, 2-11.6

4.5.6 Storage temperatures in chemical storage areas shall be maintained within the recommended storage temperature range for the materials being stored.[14]

NFPA 432, 2-4.2

4.5.6.1 High and low temperature switches, as applicable, shall be provided in addition to normal temperature controls. These switches shall actuate an alarm to ensure prompt response.

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14 [4.5.6] Attention should be used to ensure that **organic peroxides** stored in direct sunlight are not heated above allowed temperatures by radiant heating.

NFPA 432, 2-4.3

4.5.6.2 Heating systems shall use low-pressure steam, hot water, or indirectly heated air; cooling systems shall not use direct expansion of a flammable gas.

NFPA 432, 2-4.4

4.5.6.3 Heating or cooling pipes and other heat transfer devices shall not come into contact with organic peroxide containers to cause their overheating or cooling.

NFPA 432, 2-5.2

4.5.7 Refrigerators used for storing organic peroxide formulations shall be Class I, Group D, and Division I (i.e., "explosion-proof", as defined in Article 500 of NFPA 70.

Appendix A
Source Documents

ANSI Z49.1 (1994), "Safety in Welding, Cutting and Allied Processes."

CGA G-1 (1996), "Acetylene."

CGA P-1 (1991), "Safe Handling of Compressed Gases in Containers."

DOE Order 440.1A, " Worker Protection Management For DOE Federal And Contractor Employees."

NFPA 30 (1996), "Flammable and Combustible Liquids Code."

NFPA 45 (1996), "Standard on Fire Protection for Laboratories Using Chemicals."

NFPA 51 (1997), "Standard for the Design and Installation of Oxygen-Fuel Gas Systems."

NFPA 55 (1998), "Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders."

NFPA 430 (1995), "Code for the Storage of Liquid and Solid Oxidizers."

NFPA 432 (1997), “Code for the Storage of Organic Peroxide Formulations.”

UFC (1997), Uniform Fire Code, 1997 edition.

29CFR 1910.6, "Incorporation by Reference."

29CFR1910.106, "Flammable and Combustible Liquids."

29CFR1910.134, "Respiratory Protection."

29CFR1910.253, "Oxygen-Fuel Gas Welding and Cutting."

29CFR1910.1200, "Hazard Communication"

29CFR1926.350, "Gas Welding and Cutting."